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PROCEEDINGS

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EFFECT OF NON-IONIC POLYACRYLAMIDES ON SPRAY DROPLET SIZE, SPRAY DRIFT AND PESTICIDE EFFICACY

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SUMMARY

Research was conducted to study the effect of high and low molecular weight polyacrylamides on the droplet size and spray drift potential of glyphosate sprays and to study the effect of polymer on glyphosate efficacy. The high molecular weight polymer had a much greater effect on increasing the VMD and reduced the 'driftable' fraction of the glyphosate spray than the low molecular weight product. Surprisingly however both polymers increased the efficacy of glyphosate in growing room trials.

INTRODUCTION

It is well known that linear, high molecular weight water-soluble polymers, such as polyacrylamides, reduce the tendency of aqueous sprays and jets to break up. Thus, in an agricultural spray, the average size of the droplets is likely to be increased and the number of 'driftable' droplets reduced Consequently, these polymers have been used as 'anti-drift' agents in agriculture. Many studies have been conducted on the effect of polymers on spray patterns using different nozzles and pressures. There are however fewer studies where measurements have been made on actual pesticide sprays nor have there been reports of how modification of the spray pattern has influenced the efficacy of the product.

This paper describes the effect of two polyacrylamides on the droplet spectrum, driftability and efficacy of agricultural sprays of glyphosate. The polymers differed in molecular weight (MW). It was anticipated that the polymer with higher MW would modify the spray pattern significantly, whilst the low MW product would have little influence.

MATERIALS AND METHODS

Polyacrylamides

Two different formulations of a linear homopolymer of acrylamide (both manufactured by Allied Colloids Limited) were used.

The higher MW product DP10-4291, is a stabilised suspension in a mineral oil of polyacrylamide (25%) of particle size <3 μm and Intrinsic Viscosity (IV) 8 dl/g. The oil contains an emulsification system (6.5%) consisting of a proprietary blend of non-ionic surfactants. Addition of DP10-4291 to water with stirring results in emulsification of the oil phase. Exposure of the polymer to water results in its dissolving and viscosifying the aqueous phase. The low MW product, DP10-5830 is an aqueous solution of polyacrylamide (12.5%) with IV 2 dl/g.

Spray atomisation
Particle size measurements of spray droplets were recorded on a Malvern Laser beam particle size analyser.

Lurmark flat fan 110° nozzles were used under the conditions shown in Table 1.

Table 1. Nozzle sizes and pressures used to produce reference spray qualities and volume rates.

Nozzle Size	Pressure (bars)	Spray Quality	Spray Volumes Rate (1/ha)
4110 10	4.0	very fine	90
4110 14	2.0	fine	125
4110 20	1.7	medium	200

DP10-4921 was included in the spray mix at a rate of 0.1% v/v and DP10-5830 at a rate of 0.2% v/v of the spray solution. These both correspond to a polymer dosage of 0.025% v/v.

The following commercially available reagents were used:

Glyphosate (N-(phosphonomethyl) glycine) containing 360 g/l glyphosate acid as its isopropylamine salt (Roundup; soluble concentrate [SL]; Monsanto) at a concentration equivalent to 540 g ae/ha. An alkyl phenol ethoxylate non-ionic surfactant containing 948 g/l ai (Agral) at a rate of 0.1% v/v of the spray solution.

The results are recorded as Volume Mean Diameter (VMD) of the droplets and the percentage 'driftable' (% drift), arbitrarily defined as the percentage of droplets below 104 µm in diameter.

Growing room experiments
Winter barley (var Igri) was grown on trays of pouing compost (10 seeds per tray) in a growing room.

Spray treatments were applied at the 2-3 true leaf stage using a propane pressurised sprayer, fitted with a rotary belt (speed 4 mph) on which the trays were placed. A volume of water equivalent to 500 1/ha was applied at a pressure of 3.0 bar through a Lurmark 015 F80 flat fan nozzle. All treatments were replicated 3 times. Subsequent to spray treatment, some trays were subjected to 'rainfall' by spraying with 5 mm water from the above sprayer at a known time after treatment was applied.

Four days after treatment application, each barley plant was cut off just above its growing point. The height of regrowth was measured at regular intervals. Results for the three replicates were averaged and expressed as % regrowth (control = 100%). The number of dead plants was also recorded and expressed as % kill.

RESULTS AND DISCUSSION

Spray atomisation data

The objective of these experiments was to determine the effect of DP10-4291 on spray patterns in the presence of pesticide. As most pesticides include some surfactant in the formulation, it seemed instructive to investigate the effect of DP10-4291 on the spray pattern of water containing non-ionic suifactant. The results are summarised in Table 2.

Table 2. Effect of non-ionic surfactant and DP1O-4291 on VMD and percentage driftable droplets.

		Medium		Fine		Very fine	
DP10-4291	Surfactant	VMD	% drift	VMD	%drift	VMD	%drift
-	-	242	11	162	25	104	50
-	+	169	24	119	43	89	60
+	-	215	15	141	32	106	50
+	+	189	20	169	24	117	44

The most noticeable effect from the results above is the presence of surfactant. As one might anticipate, reducing the surface tension of the water led to a significant reduction in VMD and increase in driftable droplets for all nozzle sizes. Interestingly, DP10-4291, which contains surfactant, also gave some reduction in VMD. However addition of DP10-4291 to the water/ surfactant mix give an increase in VMD and reduction in driftable droplets for all spray qualities.

Table 3 shows the effect of DP10-4291 and DP10-5830 on the spray pattern of glyphosate formulations.

Table 3. Effect of DP1O-4291 and DP1O-5830 on VMD and percentage driftable droplets of glyphosate-containing spray.

		Medium		Fine		Very fine	
DP10-4291	DP10-5830	VMD	% drift	VMD	%drift	VMD	%drift
-	-	234	11	160	23	111	45
-	+	202	17	156	28	114	45
+	-	180	20	171	18	147	26

Whilst the results for the medium nozzle are unexpected, it can be seen that DP10-4291 increased the droplet size of glyphosate for the fine and the very fine nozzle. As anticipated, the low MW polymer, DP10-5830, had little effect on the spray quality.

Growing room data

Initial results from the growing room trials are shown in Tables 4 and 5.

Table 4. Effect of glyphosate and DP10-4291 on regrowth and kill of barley.

Glyphosate (g ae/ha)	DP10-4291 (% v/v)	Regrowth (%, day 6)	Kill (% day 13)
0	0	100	0
	0.1	102	0
120	0	100	0
	0.1	82	18
240	0	87	13
	0.1	28	72
360	0	81	92
	0.1	34	97

The results clearly show that, at all dose rates tested, the addition of DP10-4291 led to reduced regrowth and increased kill of the barley plants. DP10-4291 does not have a phytotoxic effect when applied in water however.

Table 5. Effect of glyphosate, DP10-4291 and rainfall on regrowth of barley.

Glyphosate (g ae/ha)	DP10-4291 (% v/v)	Rainfall None	0.5 h	1 h
		(% regrowth, day 6)		
125	0 %	71	103	96
	0.1 %	14	86	58
250	0 %	24	94	60
	0.1%	6	45	24

As anticipated, rainfall reduced the efficacy of glyphosate and the effect was more pronounced the shorter the gap between treatment and rainfall. However the presence of DP10-4291 in the spray solution increased the efficacy of glyphosate under all conditions.

As DP10-4291 is a mixture of polymer, oil and surfactants, it was decided to determine which of the components affected the efficacy of glyphosate. Trays were treated with a mixture of oil + surfactant and a solution of high MW polyacrylamide (made by dissolving up solid product) combined with glyphosate. The results are presented in Table 6.

The results clearly show that the increased efficacy of glyphosate was associated with the polymer and not with the oil/surfactant system.

In the final experiment, the two polymers were compared at equivalent dosages of polyacrylamide. The results are summarised in Table 7.

Table 6. Effect of individual components of DP10-4291 on efficacy of glyphosate.

Glyphosate (g ae/ha)	Additive	Regrowth (%, day 7)	Kill (%, day 13)
0	None	100	0
375	None	20	50
	Oil/Surfactant	21	45
	Polymer	3	85
	DP10-4291	9	65

Table 7. Effect of DP10-4291 and DP10-5830 on efficacy of glyphosate.

Glyphosate (g ae/ha)	Additive	Regrowth (%, day 7)
250	None	39
	DP10-4291	19
	DP10-5830	12
375	None	16
	DP10-4291	9
	DP10-5830	6

The interesting result from the above experiment was that both low and high MW polyacrylamides improved the efficacy of glyphosate, though only the high MW polymer had a significant effect on the particle size and thus driftability of glyphosate sprays. One may consider a number of factors which may influence the efficacy of glyphosate. It is however clear from the above that reducing drift and thus improving targeting is not the only factor. Other factors may include reduced bounce of droplets containing polyacrylamide, improved adhesion to leaf surfaces and improved cuticle penetration. Whatever the reasons the above results suggest the possibility of designing adjuvants which act as both anti-drift agents and activators.

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June 27, 2002

To: Exacto Customers:
From: Exacto Product Development Staff

RE: *MON-007 herbicide and use with polymer based drift/deposition adjuvants.*

Monsanto is preparing for the launch of MON-007, a new-patented potassium salt of glyphosate herbicide. The commercial introduction in the USA is currently planned for 2003. Since early June Exacto has received several requests from our customers to send samples of their polyacrylamide-based drift control products to Monsanto for testing with MON-007.

Monsanto has invited samples of all types of drift control adjuvants into their lab for the purpose of internal testing with their new herbicide. The testing was initiated because Monsanto recently discovered compatibility problems of MON-007 with some drift retardant and deposition adjuvants when trial use field-testing began in mid May. The Monsanto laboratory staff is working proactively to solve the incompatibility problems and desires to seek solutions for making the majority of commercially available drift retardants usable with MON-007. The incompatibility with MON-007 stems from a new inert/surfactant package used in the MON-007 formulation compared to Roundup Ultra and Roundup Ultra Max.

Exacto has been in contact with Monsanto and worked cooperatively with them to identify potential solutions to the compatibility problems. Monsanto has shared their testing protocols openly with us, which has enabled our lab staff to run simultaneous experiments with current, and potentially new drift/deposition products.

Through our testing, we have learned that mixing order is a critical factor with the MON-007 compatibly problems. Some products, which showed signs of incompatibility in the first series of experiments, *in fact are compatible if AMS is added first to the tank mix. For these* products, it is imperative that AMS is added first, before the drift/deposition adjuvant or the MON-007. The order of addition between herbicide and adjuvant does not appear to matter as long as AMS is always added first.

In addition to evaluating current products, our lab has also been screening new formulations that are more convenient to use and will not be susceptible to mixing order requirements. We have discovered and understand why the incompatibility problems exist and have began to identify alternative formulations to replace current products, if necessary.

To date, we have forwarded multiple experimental products to Monsanto for testing. At the present, 3 of the new experimental formulations have passed Monsanto testing, and another has been recommended for additional field evaluation before Monsanto can determine suitability.

Overall, we are confident that Exacto will be able to manage the compatibility issues with new MON-007 herbicide, and are eager to continue working with each of you in maintaining and growing your business along with ours. We appreciate your understanding and continued patience as we work through these current issues. We will keep you updated with any new information and ask that you please forward your questions and comments to your Exacto Territory Manager so that we can continue to work with you at solving these challenges.

Sincerely,
Exacto Inc.

Sylvia

Sylvia A. Nicklas, Ph.D.
Director of Product Development